FROM RUBE GOLDBERG TO TRICORDERS: ASTROBIOLOGY TECHNOLOGY NEEDS. P.J. Boston[1], [1]NASA Astrobiology Institute, NASA Ames Research Center, Moffett Field, CA 94035, penelope.j.boston@nasa.gov

Introduction: The hunt for life in extraterrestrial environments and in extreme environments on Earth presents challenging problems in strategy, science, and engineering [e.g 1]. Much of the astrobiology community comes from the science side of the house, with some notable exceptions, so it is to our benefit interest more engineers, makers, and innovators in astrobiology-related technology needs.

Biology and the various disciplines of engineering can overlap in a wide variety of ways. These include design inspired by biological entities and subsystems, the actual use of biological materials as components, what we have come to know as genetic engineering, synthetic biology, and other engineering that is in service to biological systems in a variety of ways. Technology for astrobiology purposes could fall within one or more of these categories.

Some of the most severe constraints on built items in space and in challenging planetary environments involve robustness, fault tolerance, and the potential for self-repair. Interestingly, these are challenges that biological entities also face and their solutions to these problems have been tested in the laboratory of evolutionary time and selection to provide many approaches of use to us in solving our astrobiology needs.

Fruitful interactions between the innovation community, and enthusiastic astrobiology customers can result in major capability leaps as we go forward to explore the Solar System and beyond. There are already many meetings and reports that have addressed life detection needs, but there is a broad community of expertise and creativity that has not yet engaged in astrobiological arenas that may be tapped for fresh perspectives There are five major problem areas that come to mind, which could benefit from such efforts.

Problem 1 – Simultaneous Measurements: The ability to interrogate a sample simultaneously in a wide variety of ways is of great value in the task of unequivocally demonstrating that something is alive [2]. Our current payloads have much to commend them, but they are largely focused on static or serial measurements that are often hard to translate into what we think of as ongoing life processes. The discontinuity and failure to close logical loops between datasets is a conundrum that must be solved if we are to claim definitive evidence of ongoing extant life. We are often faced with incompatibilities of methods that we would like to bring to bear on the same samples at the same time. A move towards minimally invasive or non-invasive techniques could help to advance us towards the goal of simultaneity.

Problem 2 – Long-Term Observations on Landed Missions: The ability to follow natural phenomena for protracted periods of time is very difficult to do in the mission context, but life is an ongoing process whose pace depends on many factors and can be very slow [1,3]. Our ability to successfully detect and characterize phenomena as truly life may depend upon our coming to grips with this problem.

Problem 3 - Access to Challenging Terrain: Many sites on Earth that may represent some aspects of astrobiologically promising sites on other Solar System bodies are very difficult to access even with human expertise and equipment. This task becomes even more daunting when we contemplate the robotic and sample handling needs involved. Access to chasms, caves, liquid bodies, through ice shells, dense gas oceans, and more are awaiting our creativity [e.g. 4].

Problem 4 - Seeing Like a Human: Our own evolutionary history has made us into excellent pattern recognition machines with great subtlety and the ability to make intuitive leaps of logic and interpretation. While machine learning and automatic pattern recognition are fields gaining much attention [5, 6] we still have a long way to go to sufficiently emulate humans.

Problem 5 – Affordable & Implementable Planetary Protection: The *sine qua non* of astrobiology missions to potentially inhabited parts of bodies like Mars [7, 8] and the ice-shell liquid interior moons of the Outer Solar System [9] is Planetary Protection. The justification for this is solidly based in protection of life detection science to provide unequivocal results and must be responsive to our international treaty obligations. Considering that the Viking landers were completely heat sterilized prior to their launches, this is a mission need that we can solve with a combination of new technology and smart systems engineering. Multiple methods of sterilization are available ranging from heat, steam and pressure, sterilant gases, ultraviolet light, and various types of hard radiation.

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